Distributed control of urban traffic networks using hybrid models

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Abstract

Urban traffic control poses a challenging problem in terms of coordinating the different traffic lights that can be used in order to influence the traffic flow. Model based control requires hybrid systems models consisting of interacting fluid flow Petri net models for controlled and uncontrolled intersections, and cell transmission models for links connecting the intersections. This paper proposes a simulation based distributed model predictive control algorithm for solving this problem.

1. INTRODUCTION

Classical traffic light controllers use a fixed red/green schedule that tries to optimize the system behavior under normal operating conditions, hopefully achieving green waves most of the time. Recently many intersections have been equipped with more or less sophisticated vehicle detectors that could be used for implementing a feedback control that only gives a green light to a side road when there are cars waiting there. This feedback policy may however destroy the green wave of the open loop controller. The challenge is to coordinate the feedback actions at neighboring intersections so that no green time is wasted on directions where no cars are waiting, but at the same time so that green waves are preserved as much as possible.

2. Model

An urban traffic network consists of many interacting components, like controlled and uncontrolled intersections, and road links connecting those intersections. Intersections are best modeled by as a queueing model considering the road space as a service station, that is assigned to different traffic streams according to some priority rule (controllable or not). In order to obtain a simulations model that is sufficiently fast to be applied in an MPC controller we propose a fluid Petri net model of these queues [2]. For the short links connecting the intersections a simple time delay may be a sufficiently accurate model, but for longer links a cell transmission model [1] is proposed. Connecting these different components together into one simulator leads to a hybrid systems model of the plant.

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3. Coordinating Control

In order to solve the optimal coordination control problem a distributed approach is necessary. This means that the local controller for an intersection will use local measurements on queue lengths, arrival rates, and other local state information, together with summarized data that coarse describing the state at neighboring intersections, and some control parameters generated by a supervising controller. In fact each local controller should not even have to know the detailed model of its neighbors, since this could not be reliably updated anyway. Hence each local controller could not even interpret detailed data from neighbors. The supervising controller also knows only this coarse model of each intersection.

In order to obtain the optimal coordinator the distributed Model predictive Control, as proposed by Krogh et al. [3] is used. The model predictions required for this controller are obtained by running the distributed simulator developed for the urban network.

References:

compositional Stochastic model for real time freeway traffic simulation, in Transportation Research. Part B - Methodological, vol.40 (2006), pp.319-334.

[2] Jorge Jlvez and Ren Boel: Modelling and controlling traffic behaviour with continuous Petri nets, Proceedings of the 16 IFAC World Congress on Automatic Control, Prague 2005

[3] E. Camponogara, D. Jia, B. H. Krogh, and S. Talukdar, Distributed model predictive control, IEEE Control Systems Magazine, vol. 22, no. 1, pp. 44-52, Feb. 2002